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APPENDIX E E E.

CONSTRUCTION AND IMPROVEMENT OF ROADS AND BRIDGES IN THE YELLOWSTONE NATIONAL PARK.

REPORT OF MAJOR WILLIAM A. JONES, CORPS OF ENGINEERS, OFFICER IN CHARGE, FOR THE FISCAL YEAR ENDING JUNE 30, 1890.

UNITED STATES ENGINEER OFFICE,
St. Paul, Minn., July 7, 1890.

GENERAL: I have the honor to transmit herewith my annual report, in duplicate, upon the improvement and construction of roads and bridges in the Yellowstone National Park, for the fiscal year ending June 30, 1890.

Very respectfully, your obedient servant,

W. A. JONES,
Major, Corps of Engineers.

Brig. Gen. THOMAS L. CASEY,
Chief of Engineers, U. S. A.

The project for this work was adopted in 1883, when the control was placed in the hands of officers of the Corps of Engineers, and consists in the construction and maintenance of about 225 miles of roads, with the necessary bridges, culverts, etc. The roads embraced in the project commence at Gardiner, at the north boundary line of the park; thence to Mammoth Hot Springs; thence to Upper Geyser Basin, passing through Norris Geyser and Lower Geyser basins; thence to the outlet of Yellowstone Lake via Shoshone Lake and the west arm of Yellowstone Lake, crossing the continental divide of the Rocky Mountains twice; thence to Yancey's via the Falls and Grand Cañon of the Yellowstone River; thence to Mammoth Hot Springs, completing the so-called belt road with a circuit of about 145 miles. In addition, there are projected: A road from the west boundary line of the park passing through Lower Geyser Basin and continued easterly to intersect the road along the Yellowstone River to the Falls; a road from Norris Geyser Basin to the Falls of the Yellowstone; a road from Yancey's to the east boundary line of the park; and a number of short branch roads and trails from the above-named roads to objects of interest off the main line of travel; in all, 225 miles of new roads, about 20 large and fifty small bridges, with many culverts, etc. Estimated cost, as revised in 1889 by my predecessor, $444,779.42.

At the beginning of the year the roads that were open to travel were:

Completed roads.—(1) The road from Gardiner to Mammoth Hot Springs, Norris, Lower and Upper Geyser basins, completed, except a projected stretch of 10 miles of new road in Gibbon Cañon, designed to replace an equal length of the old road, and some minor changes in the location of different parts of the road. (2) The road from Norris Geyser Basin to the Falls of the Yellowstone.

Uncompleted roads.—(1) The road from Yellowstone Lake outlet to the falls. (2) The two roads known as the Madison Cañon road and Howard trail, from the western boundary line of the park to Lower Geyser Basin, where they join, and their continuation as one road to the uncompleted road from Yellowstone Lake outlet to the falls. (3) The road from Mammoth Hot Springs to Yancey's and its continuation to Clark's Fork mine.

The work during the past fiscal year was commenced July 1, 1889, and continued to September 24, when operations were suspended, except some small repair work, until April 15. There being no funds available as yet for continuing the work during the ensuing year, operations were brought to a close June 30, to await an appropriation by Congress.

The work accomplished during the year has been: (1) The construction of a part (1.1 miles) of the new road in Gibbon Cañon; a temporary connection was made with the old road at Cañon Creek, thus making the new part available for travel. The portion completed closely follows the river and in places was built in the stream. Two new pieces of road 1,600 feet and 6,700 feet in length were build around Brick-yard Hill and in the Swan Lake Basin respectively. The former obviates a bad hill and the latter avoids a soft piece of the old road. The above are all on the main line from Mammoth Hot Springs to the Geyser basins. (2) The road from Upper Geyser Basin to the outlet of Yellowstone Lake was commenced at both ends of the line by clearing off the timber and building bridges, except at the two crossings of the Firehole River. Grading was resorted to only where necessary. The parties working from the Upper Geyser Basin opened up in this way 3.5 miles along the Firehole River, while the parties at the other end opened up 7.4 miles of nearly level road along the lake shore and through heavy timber. It is estimated that $5,450 will complete the 10.9 miles opened up this year. (3) The road from Norris Geyser Basin to the Falls of the Yellowstone was continued 6,200 feet down the Grand Cañon to the new hotel site; of this distance, 2,225 feet were built on the precipitous side of the cañon, requiring a long retaining-wall. (4) The roads and trails in use were kept in repair.

The work was carried on by hired labor, and the purchase of materials and supplies after due advertisement and under sealed proposals. The hire of teams was made by advertisement and a formal written contract.

Summary of work done during the fiscal year.

New roads built	miles	3.85
New roads opened but not completed	do	10.90
New roads repaired and maintained	do	56.00
Old roads repaired and maintained	do	60.25
Bridges (trestles) built; two 90 feet long, two 30 feet long, seven 15 feet long, number		11
Bridges repaired	number	1

The total work done in the park by the engineers, commencing in 1883, is as follows:

New roads built	miles	62.85
New roads opened but not completed	do	10.90
Original wagon roads and trails repaired	do	63.50
Large and small bridges built	number	32

In addition, about 48 miles of old roads and trails were repaired, more or less. They have since been abandoned.

Amount expended during the fiscal year ending June 30, 1890, including outstanding liabilities	$50,000.00
Total amount expended upon the project since commencement of work in 1883 to June 30, 1890, including outstanding liabilities	184,779.42

GENERAL CONSIDERATIONS.

Roads are made for traffic. They are subject to a great deal of wear and tear. Waters wash away their surface; winds blow it away in dust; wheels and hoofs cut it up. The quantity of wear varies directly with the hardness of the surface. The harder it is, the less the cost of keeping it in repair. The annual cost of keeping a soft road in order will, when capitalized, be more than sufficient for making the surface hard. Soft roads are extravagant and wasteful except where the traffic is insignificant.

The project under which we are working calls for the construction of about 225 miles of road, at a total cost of $444,779.42. This is about $2,000 per mile, and does not include maintenance during construction. This is for constructing a road in rugged, mountainous country, densely timbered and swampy. It will involve some expensive feats in engineering. Evidently the estimate does not look beyond clearing the line of trees and brush and a moderate grading, making what is usually called a country road. The maintenance of such a road under the traffic which may reasonably be expected will be relatively expensive. It will be at the mercy of wind and water, and unless the surface be kept moist during the dry season the dust will be an intolerable nuisance. Such is the case over the portion now in use. The soil of the region is very light, and the summer atmosphere is exceedingly dry, with scarcely any precipitation of rain. I propose to organize a system of current repairs similar to that in use on railroads and to combine it with regular sprinkling over the lightest portions during the months of July, August, and September. It is proposed to carry forward the project to the point of making passable roads throughout the park at the earliest moment. When this shall have been accomplished it will be essential, from a business point of view, to proceed at once with covering the roads with a 6-inch layer of broken stone, well crowned, guttered, and drained, and thereafter to keep small repair parties continuously at work upon the general maintenance of the system.

The line of road proposed for construction is fully described in preceding reports. The magnitude of the proposition and the grandeur of the conception of the park may be better realized when we consider that its boundary is a rectangular figure with sides about 50 and 60 miles in length.

The appropriations for this work have so far been made under an "annual" appropriation, which has to be expended during the fiscal year for which it was made. In this class of appropriations all balances unexpended at the close of the fiscal year revert to the Treasury, so that, during the long sessions of Congress, on the 1st of July the work suddenly finds itself out of funds. Since the appropriation bills are usually passed some time in July or August, all hands have to be discharged right in the best part of the season. Everything has to be cleared up, carted a long distance and stored, and we have to trust to luck for assembling our experienced hands a month or so later when the new appropriation becomes available. Now, the working season at such high altitudes is very short, from May to October at best, and the operation of cutting it in two in the middle is not wise. This matter can easily be remedied by adding to the appropriation section a proviso that the funds shall be available until wholly expended, whether within the fiscal year or not. Another proviso to the effect that the Secretary of War may carry on the work by contract or otherwise as may be most economical and advantageous to the Government would have the effect of placing it on exactly the same status as the appropriations for river and harbor improvements. The work being of the same character and being conducted under the same organization and methods, this work would be placed upon the same advantageous plane for economical administration as those.

It is proposed during the coming year to carry forward the project for opening new and maintaining completed roads with the utmost vigor. Owing to the remoteness of the locality and the absence of lines of supply it is difficult to maintain many parties along the line of new road, so that not more than $150,000 can be advantageously expended. With this it is expected to open at least 65 miles of new road and to maintain the completed roads in such condition as to make traveling reasonably comfortable and free from the dust nuisance.

In conclusion I wish to acknowledge the assistance rendered by Lieut. W. E. Craighill, Corps of Engineers, who has been in local charge of the work, and by Mr. E. Lamartine, overseer. Lieutenant Craighill's report, herewith, is referred to.

ABSTRACT OF ALLOTMENTS AND APPROPRIATIONS.

Allotments.

Under the appropriation of 1883	$23,570.03
Under the appropriation of 1884	23,000.02
Under the appropriation of 1885	23,209.37

Appropriations.

By act approved August 4, 1886	20,000.00
By act approved March 3, 1887	20,000.00
By act approved October 2, 1888	25,000.00
By act approved March 2, 1889	50,000.00
Total of allotments and appropriations	184,779.42

Money statement.

July 1, 1889, amount available		$50,000.00
July 1, 1890, amount expended during fiscal year, exclusive of liabilities outstanding July 1, 1889	$45,174.87	
July 1, 1890, outstanding liabilities	4,825.13	
		50,000.00
Amount appropriated by act of August 30, 1890		75,000.00
Amount available for fiscal year ending June 30, 1891		75,000.00
Amount (estimated) required for completion of existing project		260,000.00
Amount that can be profitably expended in fiscal year ending June 30, 1892		150,000.00

Abstract of proposals for team-hire opened July 6, 1889, by Maj. Charles J. Allen, Corps of Engineers.

[Horse or mule teams with drivers and equipment.]

No.	Name and address of bidder.	Teams.	Price per team per day of eight hours.
1	Peter Larsan, Helena, Mont	35	$4.49
2	Alex. Young, Mammoth Hot Springs, Wyo	35	*4.34
3	Paul McCormick, Junction City, Mont	35	4.89

*Accepted.

REPORT OF LIEUTENANT WILLIAM E. CRAIGHILL, CORPS OF ENGINEERS.

MAMMOTH HOT SPRINGS, WYO., *June* 30, 1890.

MAJOR: I have the honor to submit herewith my report on the construction and improvement of roads and bridges in the Yellowstone National Park during the fiscal year ending June 30, 1890.

Fifty thousand dollars was appropriated by the act approved March 2, 1889, and work was commenced on July 1.

The work has been done by day's labor, the necessary teams being furnished by contract under sealed proposals. The force employed during the summer of 1889, without material change, consisted of 1 overseer, 1 time-keeper, 4 foremen, 1 assistant foreman, 1 sawyer, 1 engine-driver, 2 blacksmiths, 5 cooks, 111 laborers, 1 water-carrier, 35 teams.

By the terms of the contract for the teams, the contractor supplied a driver for each two animals, and the necessary outfit of scrapers, chains, harness, and blacksmith tools. He also fed his animals. Laborers were hired by the day, and, with the drivers of the teams, were fed at the expense of the Government.

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On the 28th of September the work of construction ceased for the season, and all laborers and teams were discharged except a small party for some necessary repairs to the road between Mammoth Hot Springs and Gardiner. These were kept until a few days into October when active operations were suspended. Work might have been continued for a week or two longer without serious inconvenience from the weather, but the money was beginning to run low and it was necessary to save some for repairs in the following spring.

During the winter the property stored at Mammoth Hot Springs was guarded, and a small amount of necessary work was done on the road between Gardiner and Mammoth Hot Springs by laborers hired for the occasion.

In the spring of 1890 operations were recommenced on the 15th of April, nearly a month later than the preceding season. At that date it was impossible to get farther into the Park than Mammoth Hot Springs, except on snow-shoes. The work of repairing the roads and getting them ready for the summer travel continued without interruption until the 27th of June. On the 30th of June the entire force employed was discharged on account of lack of funds, and the work completely suspended.

CONSTRUCTION WORK.

(1) *At the Grand Cañon of the Yellowstone.*—The work at this point consisted in completing the new road down the Cañon of the Yellowstone to give access for wagons to the new hotel there and to the points of interest below Cascade Creek.

The point at which work was carried on is about 32 miles from Mammoth Hot Springs and about 40 miles from the railroad. The total length of new road is 6,200 feet. The total cost per mile was $8,365.66. Two thousand two hundred and twenty-five feet were built on the precipitous side of the Cañon of the Yellowstone River, requiring a retaining-wall containing about 3,700 cubic yards of rock.

The material excavated on the sides of the Cañon consisted generally of a soft rock or hard clay interspersed with bowlders. It was difficult to handle, but since it has become compacted makes an excellent road-bed.

On the side hill the average width of the road is about 20 feet. Two bridges were included, both of which were described in the last Annual Report.

(2) *Between Yellowstone Lake Outlet and the Upper Geyser Basin.*—This is on the

route which when fully opened will give access to Shoshone Lake and the western end of Yellowstone Lake. The work was prosecuted at both ends of the line, *i. e.*, on the Yellowstone Lake and on the Firehole River above the Upper Geyser Basin.

Intermediate points being inaccessible to wagons, it was not economical to have working parties except at the two ends. As far as possible the work was confined to clearing the timber away and building bridges, and grading only where necessary. It is estimated that $500 per mile will be necessary to complete the part of the road constructed this year. On the Yellowstone Lake the road follows closely the shore of the lake and is almost level throughout.

The site was heavily timbered with a large proportion of spruce trees in the western end. This variety of tree caused greatest trouble, because of its luxuriant growth and because of the number of its roots extending in all directions just under the surface. Seven and four-tenths miles were opened. In this distance there were eleven trestle bridges built, two of which are 90 feet, two 30 feet, and seven 15 feet long. The total amount of material contained in them is about 150,000 feet, B. M.

On the Firehole River above the Upper Geyser Basin 3½ miles were opened. In this distance there are two crossings of the Firehole River. These will be made by trestles, the bill of material for which has nearly been sawed out. About 50,000 feet were sawed at this point, but nothing further was done toward building the bridges. The total length partly completed between the Yellowstone Lake and Upper Geyser Basin was 10.9 miles, at a total cost of $17,735.81, or at an average cost per mile of $1,627.14.

(3) *In the Gibbon Cañon.*—This road was projected to replace about 10 miles of the old road between Norris and the Lower Basin Hotel. It begins at a point in the Gibbon River about 2½ miles from the northern end of the cañon and about 27 miles from Mammoth Hot Springs. The new road as far as completed is close to the river's edge, and in places was built partly in the bed of the stream.

The project contemplates carrying the road to the hotel at the Lower Geyser Basin, but the end of the work was only brought to the mouth of Cañon Creek, where a temporary connection was made with the old road. The average cost per mile was $4,073.70. Considerable difficulties were encountered on account of numerous springs and swampy places, and for about half the distance the side-hill cutting was heavy.

(4) *Around the Brick-Yard Hill.*—The work at this point was a small piece, designed to replace one of the bad hills between Mammoth Hot Springs and Norris. The location is about 14 miles from Mammoth Hot Springs. The work was executed in June at a total cost of $672.14. The total length constructed was 1,600 feet, of which 1,100 feet were covered with timber. The work was done at a rate of $490.03 per mile for removing timber, and at a total expense of $2,218.06 per mile.

(5) *In Swan Lake Basin.*—About 5 miles south of Mammoth Hot Springs, near Swan Lake, for about 1¼ miles the road had never been graded. In the spring and fall at this point the mud was very deep, and at other times the road was rough. The new road obviates the difficulties at this point. When work ceased it was nearly complete, sufficiently so to allow vehicles to pass over it. Its length is 6,700 feet, and its cost $1,167.67, or at the rate of $920.93½ per mile.

BRIDGES.

Eleven bridges were built during the year, all trestles. Two were 90 feet, two 30 feet, and seven 15 feet long. All were of a uniform pattern, the bents of 10 by 10-inch sawed timbers well braced; distance between bents 15 feet. The floor consists of two courses of 2-inch plank, the lower course laid diagonally across the stringers, which were seven in number and 8 by 10 inches in cross-section.

The design adopted for a truss-bridge for a 40-foot span (the longest yet found necessary) is shown on the accompanying drawing.*

It has been found necessary in building all the bridges, at once to have them of the simplest design and yet strong enough to carry heavy loads and be able, in the event of failure of appropriations, to go safely for a number of years without repairs. In the winter time they are probably subject to quite heavy loads of snow.

On M y 27 experiments were made on the weight of snow from a drift in Kingman's Pass. Its weight was found to be 38¼ pounds per cubic foot. On a bridge in the same locality there was a few days before that date a drift of similar snow 4 feet 8 inches deep. Assuming that its average weight was 38¼ pounds per cubic foot, the load on the bridge was 178½ pounds on each square foot. But the most serious strains are felt in such portions of the bridges as railings and retaining walls where drifts accumulate when the snow settles. Many rails of 4 by 4 inch pieces supported at intervals of 14 feet were broken by this action. Taking the transverse strength of the wood at 500 pounds, the strain required to break a stick 4 by 4 inches with 14 feet between points of support, would be 979.6 pounds per square foot.

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* Omitted.

GENERAL REPAIRS.

During the summer a small repair party consisting of one assistant foreman, three laborers, and one team was maintained. This party moved from place to place as was found necessary.

By the end of the fiscal year the wagon roads had been thoroughly repaired throughout the entire length traveled, at a total cost of $7,500.10.

The road through the Gardiner Cañon is most difficult to maintain. It passes under a mountain side down which large rocks frequently roll, especially during storms, making the road extremely dangerous. The location at this point should be changed. The cost of repairs would, I think, be reduced by having a larger number of men engaged on that work throughout the summer. They should be divided into several independent parties, each in charge of a certain section of road, upon which it would be constantly engaged.

The lumber used was sawed by the portable mill purchased at the beginning of the season of 1889. Its performance has been very satisfactory. It has moved without serious accident or difficulty from place to place so as to be near as possible to the site of the bridge in process of construction. The cost of manufacture has been about $5 per 1,000 feet, B. M.

RECONNAISSANCE IN THE SOUTHERN PART OF THE YELLOWSTONE NATIONAL PARK, AUGUST, 1889.

Under instructions from Maj. Charles J. Allen, Corps of Engineers, I made a reconnaissance in the month of August of the region about the southern portion of the park.

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The only instruments carried on the trip were an aneroid barometer with its attached thermometer and a pocket compass. Elevations given in this report are therefore approximate only, and distances are estimated.

After examining the country passed over, I am convinced that if the Union Pacific Railway wishes to make an entry into the park from the southern side, unless there is some very serious obstacle outside, they should make their point of entry where the Snake River crosses the southern line.

A good wagon road could then be easily built from this point to the outlet of Shoshone Lake, connecting at that point with the belt road now in course of construction. This road would be a good one to travel over when completed because it would have no bad hills and it would be inexpensive to build. Lewis Lake would afford a good location for a hotel, which would be only 12 miles from the railroad, and about a half a day's drive from each of the proposed hotels at the west end of the Yellowstone Lake and of Shoshone Lake. If the point of entry is selected in Falls River Basin instead of on Snake River the conditions are all unfavorable for the wagon road to the points of interest in the park. The nearest point with which connection could be made is the west end of Shoshone Lake, distant from Fall River Basin about 20 miles, but between the two is the Continental Divide, rising to a height of 8,500 feet, or 2,000 feet above Falls River Basin, and about 750 feet above Shoshone Lake. The country through which the road would pass is extremely rugged and difficult, and the road would be expensive to build and disagreeable to travel over on account of the long and probably steep hills it would have. It would also be one of the last to be clear of snow in the sping. The last is one of the strongest arguments in favor of Madison Cañon route as against any point on the southern line. An interesting report on this subject, by Mr. R. Hering, is to be found in "The Sixth Annual Report of the U. S. Geological Survey of the Territories, embracing portions of Montana, Idaho, Wyoming, and Utah, being a report of progress of the explorations for the year 1872, by F. V. Hayden, United States geologist."

The number of tourists who come with camping outfits from the south is sufficient to warrant the expenditure of the small sum that would be necessary to keep clear the trail they travel over. They follow Sheridan's trail to Shoshone Lake, thence by the trail to Upper Geyser Basin, then on the wagon roads through the park, returning to the outlet of Yellowstone Lake, and from there to Shoshone Lake again, and then over Sheridan's trail to the southern boundary.

During the summer a small repair party went over all of the pack trails included in this route except that south of Lewis Lake. In this unimproved part of the route there are in all about 5 miles, the scenes of former forest fires, very much obstructed by fallen timber. As early as practicable next season this ought to be cleared away. The expense would probably not exceed $200.

Respectfully submitted.

WM. E. CRAIGHILL,
First Lieutenant, Corps of Engineers, U. S. Army.

Maj. WILLIAM A. JONES,
Corps of Engineers, U. S. A.